# Free Radicals and the Wholeness of the Organism

***Once thought to have no role other than to kill microbes, free radicals are now understood to be crucial to generating the light energy needed to organise and fuel biochemical processes.***

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Today we know a great deal about the living world: the myriad beautiful forms of animals and plants, and how they behave and interact with each other. On the other hand, by taking them apart, we also have a compendium of knowledge on anatomy, physiology and biochemistry—now including even sequences of their genes. But between these two is a huge gap. We lack knowledge of the basic essence of life. What is it, in physical terms, that distinguishes the living state of matter from the non-living state?

Big changes have been underway, however, for at least the last 30 years. Indeed, they could be said to have begun with the publication in 1944 of Erwin Schrödinger's seminal little book, *What is Life?*[1] He was among the first to suggest that the unique properties of life could only be approached through quantum physics. Although it has yet to be much recognised by mainstream biology, we now have a firm foundation for a real, holistic biophysics—one which is already putting holistic medicine on a truly scientific basis and will surely give us many new insights, extending even into ecology and our relationship with the living world.

**Free radicals and quantum biology**

A free radical is any atom or molecule which has one of its valencies unsatisfied. This leaves it with an unpaired electron in its outer shell. In trying to get a pair for the lone electron, free radicals react avidly with any neighbouring molecules and so can, in principle, do a lot of damage. According to much contemporary health literature, therefore, free radicals are only bad news, being seen as the cause of many diseases and even as the major cause of ageing. While test-tube experiments show that they can indeed damage many important biological molecules, there is now, as we shall see, considerable evidence in support of a role for free radicals in the very basis of life.

The case for this has been powerfully argued by Professor Vladimir Voeikov, who is professor of biology at Lomonosov Moscow State University. He stems from a long and distinguished tradition of biology in Russia which has been largely ignored in the West. Some of the most convincing evidence comes from his own recent experimental work. What I write here is based on his publications—and especially an article entitled "Reactive Oxygen Species, Water, Photons and Life".[2] In the broad sweep of this illuminating article, he gives us a new conception of how molecules cooperate holistically to make a living being, and even a new and credible schema for the origin of life. We can see how free radicals are a key to understanding the central (but rarely acknowledged) mystery of biochemistry: how all the multifarious chemical reactions are integrated into a unitary living being.

All biochemical processes are transactions of energy. So first we must remember that energy is packaged into precisely defined units called *quanta*. The energy content (or "size") of a quantum is measured in electronvolts and depends on the frequency; thus a quantum of light is bigger than one of infrared or microwave. A molecule which absorbs a quantum stores the energy as some kind of higher energy state. In the case of infrared quanta, these are a variety of states of molecular vibration. But a light quantum has sufficient energy to push an electron out of its stable ground state (or *orbital*) into a higher energy orbital. The molecule is then said to be in an *electron-excited state* (EES). But all these high energy states are unstable, and after a while the energy is released again as a quantum of the appropriate frequency. So in the case of an EES, the electron jumps back again to its stable orbital and a quantum of light energy is released. This quantum can then either be directly transferred to another molecule (where it may contribute to a chemical reaction) or be emitted as a photon of electromagnetic radiation. In turn, this photon can either be absorbed by another molecule or be lost as heat.

Most biochemical reactions, as studied in the test-tube, involve transactions of infrared quanta rather than light. This is one reason why the importance of light in the living being is still not generally recognised in the West. It is a different story in Russia, where they have benefited from the work of Alexander Gurvich—a scientist who in due course will be counted as one of the world's great names in biology. As far back as the 1920s, he discovered that dividing cells produce an ultra-weak light radiation (now termed *biophotons*) which could stimulate mitosis in resting cells. Even then, it was clear to Gurvich that this light constituted an information-bearing signal. This finding lent support to his field theories of biological organisation—theories which had come so long before their time.

Since then, scientists from many countries have contributed to the development of what may be called *quantum biology.* While it has not been entirely proved to the satisfaction of the mainstream, all this work is pointing to the conclusion that a living being is unified by a single quantum wave function, in the same way that an atom or molecule is. (For further reading, see Dr Mae-Wan Ho's excellent book *The Rainbow and the Worm.*[3]) In this conception, light plays a central role; and excited electrons, rather than being confined to single atoms or molecules, are understood to be de-localised and shared at least over large molecular ensembles and probably the whole organism. Moreover, as the EESs decay, they are continually regenerated. Thus an organism normally stores a lot of light.

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### Reactive Oxygen Species

How is this light generated? It is here that free radicals come onto the scene. Professor Voeikov makes the critical point that none of the usual biochemical reactions is of sufficient energy to generate light. This can only be done by the reactions of free radicals.

All the radicals of biological significance are derived from oxygen. Principal among these are the superoxide anion radical $O_2^-$ and the hydroxyl radical HO. In addition, there is an electronic re-arrangement of molecular oxygen called *singlet oxygen*, $^1O_2$. While not a radical, it has a comparably extreme reactivity. Together, these are now termed *reactive oxygen species* (ROS). Also important are certain molecules which can easily break down to become ROS—notably, hydrogen peroxide and ozone. All these are generated by a variety of enzymic and non-enzymic mechanisms which were initially thought to be confined to cells of the immune system—especially neutrophil leucocytes. For this reason, the only function for free radicals was thought to be to kill microbes. However, these mechanisms (and there is a growing list of them) were later found to be ubiquitous throughout the body.

The body produces large quantities of ROS all the time. Indeed, it is a remarkable fact that some 10 to 20 per cent of all the oxygen we breathe enters this pathway. Along with this, some other facts should be taken into account. Thus, in the human being, the brain uses some 20 per cent of the oxygen we take in, and yet it has relatively few mitochondria. Since mitochondria are well known to be the sites where oxygen is used to generate the energy molecule ATP, most of the oxygen used by the brain must represent a different type of metabolic pathway.

Of further interest are observations by Erwin Bauer, another outstanding Russian biologist, in 1935. He collected data for the total oxygen consumption during the whole life of each of a great range of animal species, divided by the mean body weight of each. This index, called by him the "Rubner constant", increases by several thousandfold in a sequence starting with the primitive coelenterates and ending with the primates. It stands, in fact, as the only known quantitative parameter which defines evolutionary progress. Note especially that for *Homo sapiens*, this parameter is at least 10 times higher than for other primates.

This finding might suggest that as more highly developed organisms must have more complex control systems, they would need to store more light in their bodies. And for this, they would need more oxygen to generate the necessary ROS.

The facts just stated are hardly consistent with the current prevailing view that free radicals are merely noxious errors of metabolism. That they are produced in such quantities can only mean that they have an important function. And although free radicals can in principle do damage, there are several means by which this is almost completely avoided *in vivo.* One is that the radicals are produced exactly where and when they are needed and are used immediately, so that the concentration in the body at any one time is extremely small. And then there is the fact that radicals can neutralise each other, and so any unused ROS react preferentially with each other rather than damaging biological macromolecules. Finally, a back-up defence is provided by various anti-oxidants such as vitamins C and E. The efficiency of these mechanisms can be seen in the fact that, during some methods of ozone therapy, a sample of blood is mixed with ozone and re-injected into the body. This quantity of ozone, which would play havoc with isolated blood proteins in solution, has no adverse effect on living blood.

To begin to understand the main function of ROS, we must again emphasise the mysterious perfection of biological organisation, even of a single cell. The characteristic wholeness of an organism must have been present from the beginning; that is, long before the molecular signals, such as hormones and neurotransmitters, evolved. Such wholeness could not have been achieved by molecular signals alone, because these require time to diffuse towards their receptors. Instead, it would seem to require an underlying network of essentially instantaneous communication. This is what is now coming to be understood as a field of de-localised electrons excited by light energy—now often termed a *photon field.*

Furthermore, as maintained by Dr Mae-Wan Ho, for all life's processes to hang together they must also cohere into a single, complex, rhythmic order in which the fastest rhythms (and these are very fast: resonant energy transfer between molecules takes about $10^{-14}$ seconds) are nested into progressively slower ones, such as brain waves, heartbeat and hormonal cycles, ultimately to the slowest: the life cycle. Indeed, rhythmic oscillations are a hallmark of biological organisation since they indicate collective behaviour among molecules which, in isolation from each other, would behave randomly.

### Oscillatory self-organising processes with biophotons

It turns out that sustained oscillations, indicating self-organisation, have been found in a number of processes involving ROS. Studying the output of biophotons from isolated blood,

Voeikov and his colleagues found first that this increases greatly on stimulation of ROS production with zymosan [a carbohydrate obtained from yeast cell walls]. Most remarkable was the emergence, under certain conditions, of well-marked oscillations. The regulatory role of these biophotons became obvious from the effects of reflecting them back into the blood: a low basic output was increased by back reflection; high output was reduced. Even in some non-living materials, e.g., solutions of methyl glyoxal and glycine, there was both generation of ROS and release of biophotons. In such systems, too, oscillations were seen to develop.

In the living organism, the light that is actually radiated forms only a small proportion of the total light energy produced; most of it is taken up by other molecules where it serves a control function, to trigger or modulate biochemical reactions. The rhythmic release of this energy, which is capable of a wide range of frequencies—going up even to the megahertz region—is consistent with their role as pacemakers of metabolic processes. Indeed, Voeikov suggests that modulations of frequency rather than amplitude may be the most important informative factor for cellular regulation. All these complex temporal patterns (which Mae-Wan Ho likens to a symphony) are also precisely localised in space. Thus we have a deep space-time structure which is intensely dynamic in all its aspects. Perhaps it could be imagined as a non-material framework of three-dimensional music, to whose tune dance the material constituents of life.

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The finding that ROS and biophotons can so easily be produced in simple aqueous solutions has led Voeikov to propose a revolutionary alternative to the most commonly accepted understanding of the origin of life. He draws on recent evidence for dissociation of water under very mild conditions, merely by procedures such as mechanical agitation, illumination and freeze-thawing. The products of such dissociation include hydrogen peroxide and the free radicals H• and HO• derived from non-ionic dissociation of water. These radicals may then react with nitrogen and carbon dioxide to produce amino acids and other complex organic molecules. Moreover, in the presence of simple catalysts such as iron oxide, hydrogen peroxide breaks down to release oxygen.

In this way, it becomes plausible to consider a scenario where oxygen began to appear from the beginning, as soon as water appeared on Earth. Even at this time, however, ROS and EES would also begin to appear. These would soon self-organise and develop spatio-temporal structures of the characteristic dynamic stability which could begin to deserve the name Life.

### Free radicals in therapy

All this is not without medical significance. On the one hand is the finding of Chizevsky in the 1920s (which has recently been confirmed) that animals deprived of negative ions in the air became sick and died within days. On the other is the long tradition of successful therapy with ozone and hydrogen peroxide.

It turns out that negative ions are in fact superoxide anion radicals, and that a regular supply of ROS from the environment is required to "spark" the internal mechanism of oxygen reduction. Without this, the oscillations in ROS metabolism tend to decay. And then, with insufficient ROS, the radical chain reactions proceed without proper termination and go on to damage biological molecules.

The best way to neutralise these chain reactions is to intensify production of ROS by "sparking" with negative ions, ozone or other activated oxygen therapies. By regenerating the body's light energy, such therapies empower the body to cope better with whatever disease process threatens it.

Ozone therapy has a long history, and it is still being used with great success today. But it has been largely ignored by mainstream medicine—partly because its mode of action was unknown, and partly because it cannot be patented. Ozone, however, has the disadvantage of being too reactive to take into the lungs. Thus it has to be administered intravenously or by other routes requiring professional help.

So it is worth mentioning the recent and so far little-known therapy with singlet oxygen energy as developed by [the late] Tony van der Valk.[4] Air is first bubbled through water to saturate it with water vapour. It then passes a metal plate coated with a photosensitive phthalocyanin compound onto which is directed a red-light-emitting diode (634 nm).

This turns some of the oxygen into singlet oxygen. Within microseconds, the singlet oxygen (which, due to its intense reactivity, could not be breathed as such) delivers its energy to water molecule which can then be breathed with complete safety. Exactly how water carries this energy is not known at present, but the treatment is quite as effective as ozone therapy and, moreover, it is so much safer and more convenient that patients can easily administer it themselves.

As Professor Voeikov writes in his introduction, we are approaching a major turning point in biology. This is one where biology lets go of its current basis in 19th-century physics and chemistry and gains its own proper theoretical foundation. This will eventually come to have the predictive capability in relation to evolution which is lacking in Darwinism.

I hope this article will stimulate interest in such ideas, and also, by providing a *modus operandi* for the activated oxygen therapies, enhance their general acceptance in medicine. ∞

### Endnotes

**1.** Schrödinger, E., *What is Life?*, Cambridge University Press, Cambridge, 1944.
**2.** Voeikov, V., "Rivista di Biologia", *Biology Forum* 94:193-214 (2001). (I can provide copies of this article, which has all the relevant references.)
**3.** Ho, Mae-Wan, *The Rainbow and the Worm: The Physics of Organisms*, World Scientific Publishing, 1998, 2nd ed., ISBN 981-02-3427-9.
**4.** See Tony van der Valk's website, http://www.polyvalk.com.

**About the Author:**
Retired from a career of research in fundamental immunology, Roger Taylor has spent 18 years conducting research (mainly private) around the scientific basis for subtle energy. In recent work he has been using Dr Konstantin Korotkov's GDV (computerised Kirlian) system to show responses to singlet oxygen therapy and Ormus (white gold) therapy. Most of his published articles have appeared in the magazine *Caduceus*, of which he is science editor.

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